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Short communication. The effect of oestrus at slaughter on carcass and meat quality of gilts intended for dry-cured ham production

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Abstract

On the day previous to slaughter, a total of 467 Duroc × (Landrace × Large White) gilts with approximately 130 kg body weight and 242 ± 3 days of age intended for Teruel ham production were observed to detect oestrus. The behavioural manifestations described in the literature were used for this. A total of 24 gilts were positively detected and individually identified (O gilts). From the same gilts observed, a total of 24 that clearly did not manifest oestrus were also individually identified (NO gilts). Therefore, a total of 48 gilts were used to study the effect of the presence of oestrus at slaughter on carcass and meat quality. No carcass characteristics were affected by oestrus at slaughter. However, all the carcasses (100%) from NO gilts were suitable for cured ham while 12.5% of carcasses from O gilts were not suitable because of the lack of the minimum backfat thickness required (16 mm) ($p = 0.09$). The influence of oestrus at slaughter on meat characteristics was scarce. Under our experimental conditions, it can be concluded that avoiding the slaughter of gilts in oestrus might be recommendable when a minimum covering fat in carcass is needed to improve the quality of the end product. However, new trials would be needed to confirm this.

Additional key words: loin quality; pig females; stress.

Resumen

Comunicación corta. Efecto de la presencia de estro en el momento del sacrificio sobre la calidad de la canal y la carne de cerdas destinadas a la producción de jamón curado

El día previo al sacrificio, se observaron un total de 467 cerdas Duroc × (Landrace × Large White), con aproximadamente 130 kg de peso vivo y 242 ± 3 días de edad destinadas a la producción de Jamón de Teruel, para detectar la presencia de estro mediante las manifestaciones descritas en la bibliografía. Un total de 24 cerdas fueron detectadas positivamente e identificadas individualmente (cerdas O). Entre las cerdas observadas, un total de 24 que claramente no manifestaban celo fueron también identificadas individualmente (cerdas NO). Por tanto, se usaron 48 cerdas para estudiar el efecto de la presencia de estro durante el sacrificio sobre la calidad de la canal y la carne de cerdas destinadas a Jamón de Teruel. Ninguna característica de la canal se vio afectada por la presencia de estro. Sin embargo, todas las canales (100%) de las cerdas NO fueron aptas para la producción de jamón curado, mientras que un 12,5% de las canales de cerdas O no lo fueron por no cumplir el mínimo espesor de grasa de cobertura requerido (16 mm) ($p = 0,09$). El estro en el sacrificio apenas afectó a las características de la carne. Podemos concluir que podría ser recomendable evitar el sacrificio de cerdas en estro cuando se exige un mínimo de grasa de cobertura en la canal para mejorar la calidad del producto final. Sin embargo, se necesitarían más ensayos para confirmarlo.

Palabras clave adicionales: calidad del lomo; estrés; hembras porcinas.

Spain is the world leader in dry-cured ham and shoulder production with a total of 46 million pieces in 2008 (MARM, 2010). Currently, the only Protected Designation of Origin (PDO) of dry-cured ham from crossbred commercial pigs (not autochthonous) accepted by the Spanish government is «Teruel ham». The

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Abbreviations used: a* (redness), b* (yellowness), BW (body weight), C* (chroma), DFD (dark, firm and dry), H* (hue angle), L* (lightness), m. GM (*gluteus medius* muscle), NO (not oestrus gilts), O (oestrus gilts), *p* (statistical significance level), PDO (Protected Designation of Origin), PSE (pale, soft and exhudative), SE (standard error of the mean).

production of Teruel ham has increased drastically in recent decades from 2,000 pieces in 1985 to 700,000 in 2009 (CRPDO Jamón de Teruel, 2010). The Regulation of PDO Teruel ham establishes a minimum of 84 kg for carcass weight, of 16 mm for fat thickness over the *gluteus medius* muscle (m. GM) and of 11.3 kg for fresh ham to improve the uniformity and quality of the end product (BOA, 1993). In a recent study, Latorre *et al*. (2008) recommended an average slaughter weight of 130 kg to optimize the growth performance and carcass quality of these pigs. However, at this slaughter weight, all the carcasses from barrows were suitable for Teruel ham but a third of the carcasses from gilts were rejected because of the limited amount of covering fat depth (Latorre *et al*., 2009a). There are several factors that can affect the production and quality of Teruel ham from gilts (weight/age at slaughter, health status, feeding or stress). Among causes of stress, the presence of oestrus at slaughter might be important. Traditionally, the slaughter of gilts in oestrus was avoided because it was believed that it negatively affected meat quality. Currently, the Regulation of PDO Teruel ham prohibits the slaughter of gilts in oestrus (BOA, 1993). Also, Iberian gilts which are slaughtered at 160 kg of body weight (BW) are usually castrated to avoid possible negative effects of oestrus on growth performance or meat quality (Serrano *et al*., 2008). However, to our knowledge, there is no research study that justifies the effect of oestrus at slaughter on meat characteristics of gilts.

A total of 467 Duroc × (Landrace × Large White) gilts of approximately 130 kg BW and 242 ± 3 days of age intended for Teruel ham production were observed at farm during the previous day of the slaughter to detect oestrus. The behavioural manifestations described in the literature (Whittemore, 1998) were used: jaw champing, frothing at the mouth, erect ears and immobilization. A total of 24 gilts resulted positive (in oestrus; O gilts) and were individually identified. The same number (24) of gilts that resulted clearly negative (no oestrus; NO gilts) were also individually identified. Therefore, a total of 48 gilts were used to study the effect of the presence of oestrus at slaughter on carcass and meat quality. The feeding program was common to all of the animals and was based on wheat, barley, maize and soybean meal. A growing diet from 20 to 70 kg BW (2,210 kcal NE kg^{-1}, 16.9% CP and 1.00% lys) and a finishing diet from 70 kg BW to slaughter (2,340 kcal NE kg^{-1}, 14.4% CP and 0.86% lys) were provided.

When animals achieved approximately 130 kg BW, they were starved for 7 h and, on the same day, transported 130 km to a commercial abattoir plant (Jamones y Embutidos Alto Mijares, S.L., Teruel, Spain). At the abattoir, pigs were rested for 10 h with access to water but not to feed. Hot carcass weight was individually recorded because it is the first criterion used to identify those carcasses suitable for the production of Teruel ham. Therefore, carcasses that weighed less than 84 kg are not acceptable. At 45 min *postmortem*, pH and temperature in the *semimembranosus* muscle using a pH-meter equipped with a glass electrode (model 52-00, Crison Instruments S.A., Barcelona, Spain), carcass length from the posterior edge of the symphysis pubis to the anterior edge of the first rib, ham length from the anterior edge of the symphysis pubis to the hock joint, and ham circumference at its widest point were measured on the left side of each carcass. In addition, fat depth over the m. GM, and backfat thickness between the 3rd and 4th last ribs on the midline of the carcass (skin included) were measured, with a ruler with a precision of 0.5 mm, because it is the second criterion used to identify those carcasses suitable for Teruel ham production; carcasses with fat depth over the m. GM less than 16 mm are not acceptable. After 2 h at 2°C, carcasses were processed according to the simplified EC reference method (Branscheid *et al*., 1990). Loins, hams, and shoulders were then trimmed of external fat and weighed to calculate trimmed loin, ham, and shoulder yield. Ham weight is the third criterion used to identify those carcasses suitable for Teruel ham production; carcasses with fresh ham weight less than 11.3 kg are not acceptable. At 24 h *postmortem*, pH was measured as described before and hams were weighed again to calculate ham shrink losses. The incidence of pale, soft and exudative meat (PSE, as % carcasses with pH at 45 min < 5.8) and of dark, firm and dry meat (DFD, as % carcasses with pH at 24 h > 6.2) were calculated.

A section of 300 ± 20 g of *longissimus thoracis* muscle was excised at the level of the last rib from each left loin of carcass. Meat samples were stored in individual plastic bags and vacuum-packaged at –20°C until subsequent analyses. Thawing and drip losses were determined as described by Latorre *et al*. (2003). Meat colour was evaluated with a chromameter (model CM 2002, Minolta Camera, Osaka, Japan) using objective measurements (CIE, 1976). Lightness (L*), redness (a*) and yellowness (b*) were recorded and chroma (C*) and hue angle (H*) were calculated as $C^* = \sqrt{(a^{*2} + b^{*2})}$ and as $H^* = \tan^{-1}(b^*/a^*) \times 57.29$, respectively. Chroma is related to the quantity of pigments and high values represent a more vivid color denoting lack of grayness while Hue is the attribute of a color perception denoted by blue, green, yellow, red, purple, etc. related to the state of pigments (Wyszecki and Stiles, 1982). Cooking losses were determined by the method described by Honikel (1998) using a water bath (Precisterm, J.P. Selecta S.A., Barcelona, Spain) and a handheld temperature probe (model HI 9063, Hanna Instruments, Woonsocket, RI). Afterwards, tenderness was determined by a Warner-Bratzler device attached to an Instron Universal testing machine attached to a computer (Instron model 5543, Instron Ltd, Buckinghamshire, UK). Data were analyzed using the GLM procedure of SAS v. 6.12 (SAS, 1990). The treatment (presence or not of oestrus at slaughter) was included at the model as main effect. Each treatment was replicated 24 times. The incidence of PSE and DFD meat were analyzed by a χ^{-2} test. p values lower than 0.05 were classified as a significant difference and p values between 0.05 and 0.10 were classified as a trend.

A total of 857 pigs were observed at farm, 54.4% being barrows and 45.6% gilts. From all the females, a total of 24 manifested oestrus which is 6.14% of the total gilts. The proportion of O gilts was lower than expected. The reason could be that only females with clear oestrus symptoms were identified, not taking into account those that were at the beginning or at the end of the oestrus period, or delays in the puberty and silent oestrus (without clear symptoms) (Tummaruk *et al.*, 2007).

Carcass parameters (weight, covering fat depth and yield of primal lean cuts) were similar to those reported by Latorre *et al.* (2009a) for similar gilts slaughtered at 130 kg BW and also intended for dry-cured ham (Table 1). The presence of oestrus at slaughter did not modify any carcass characteristics of gilts. However, treatment affected the percentage of carcasses suitable for Teruel ham (Table 2). No effect of the presence of oestrus at slaughter was detected on the proportion of suitable carcasses with the minimum carcass and ham weights required for PDO Teruel ham. In fact, 100% of the carcasses fulfilled those requirements. However, NO gilts tended to show a higher proportion of final carcasses suitable for Teruel ham (carcasses that fulfill the three named requirements) than O gilts (91.6 *vs.* 84.4%; $p = 0.09$) because of lack of backfat thickness at m. GM (100 *vs.* 87.5%; $p = 0.09$ for NO and O gilts, respectively). This might be due to a reduction in feed intake during oestrus days as a consequence of stress. Some authors have mentioned that oestrus could lead to a lower feed consumption (Zeng *et al.*, 2002; Serrano *et al.*, 2008) but it has been not scientifically demonstrated. Le Bellego *et al.* (2002) reported a reduction in daily feed intake and in backfat thickness in growing pigs under a stress situation; housed at a high (29°C) *vs.* a thermoneutral (22°C) temperature. However, these effects could be due to the hot temperature and/or to the stress caused by hot temperature. In fact, Morrison *et al.* (2003) detected a reduced backfat depth under

Table 1. The effect of oestrus at slaughter on carcass characteristics of gilts intended for dry-cured Teruel ham

	Oestrus	**No oestrus**	**SE[a] (n = 24)**	**p[b]**
Carcass weight, kg	103.9	103.2	2.05	NS
Backfat depth at 3rd-4th last ribs, mm	26.4	26.5	1.01	NS
Fat depth at m. *gluteus medius,* mm	23.7	23.3	0.97	NS
Carcass length, cm	85.7	86.1	0.89	NS
Ham length, cm	38.4	38.2	0.28	NS
Ham perimeter, cm	76.8	77.0	0.58	NS
Weight of trimmed lean cuts, kg				
Shoulder	14.8	14.7	0.311	NS
Loin	6.6	6.6	0.147	NS
Ham	26.9	26.8	0.511	NS
Total[c]	48.3	48.0	0.916	NS
Yield of trimmed lean cuts, % carcass				
Shoulder	14.2	14.2	0.188	NS
Loin	6.4	6.4	0.098	NS
Ham	25.9	26.0	0.219	NS
Total[c]	46.5	46.6	0.410	NS
Ham shrink losses,%	1.01	1.05	0.046	NS

[a] SE: standard error of the mean. [b] p: significance. NS: not significant ($p > 0.05$). [c] Shoulder + Loin + Ham.

Table 2. The effect of oestrus at slaughter in gilts on suitable (%) carcasses intended for dry-cured Teruel ham

Requirements for Teruel ham[a]	Oestrus	No oestrus	SE[b] (n = 24)	p[c]
Carcass weight ≥ 84 kg	100	100	—	NS
Fat depth at m. *gluteus medius* ≥ 16 mm	87.5	100	0.05	+
Fresh ham weight ≥ 11.3 kg	100	100	—	NS
All[d]	87.5	100	0.05	+

[a] According to BOA (1993). [b] SE: standard error of the mean. [c] p: significance. NS: not significant ($p > 0.05$). +: $p < 0.10$.
[d] Carcasses fulfill all the above requirements.

other stress situation (a reduced pen space) but the authors concluded that it was not associated with changes in feeding behaviour but with social stress. Irrespective of the oestrus presence at slaughter, 87.5% of the gilts studied were suitable for Teruel ham. Similar results were reported by Latorre *et al*. (2008) who found that 84.2% of gilts slaughtered at 130 kg BW were suitable.

The influence of the presence of oestrus at slaughter on meat characteristics of gilts was scarce (Table 3). Meat parameters (color, water holding capacity and tenderness) were similar to those showed by Latorre *et al*. (2009b) for similar gilts slaughtered at 130 kg BW and also intended for dry-cured ham. Possible differences in meat between O and NO gilts were expected for pH, temperature or DFD/PSE meat incidence because oestrus is stressful to the gilt. A marked increase in social activities was demonstrated in gilts in oestrus which includes snout contacts between pigs, ano-genital sniffing, flank nosing and mounting (Pedersen, 2007). Meat from O gilts tended to show higher lightness ($p = 0.08$) and had a yellower ($p < 0.01$) and more intense ($p < 0.01$) colour than meat from NO gilts. This could be related to stress. It has been widely reported that a stress situation just before slaughter results in low pH values at 45 min *postmortem* and higher lightness and moisture losses (Warris, 2000). However, no named variable was affected by treatment. In fact, although O gilts showed a numerically higher incidence of PSE and DFD meat than NO gilts (20.8 *vs* 18.2% for PSE and 16.6 *vs* 9.0% for DFD), the differences were not significant ($p > 0.05$). Also, water holding capacity was not affected by the presence of oestrus. Perhaps, a higher number of replicates per treatment might have permitted the detection of significant

Table 3. The effect of oestrus at slaughter on meat characteristics of gilts intended for dry-cured Teruel ham

	Oestrus	No oestrus	SE[a] (n = 24)	p[b]
Measurements *postmortem* at m. *Semimembranosus*				
pH 45 min	5.98	6.04	0.061	NS
pH 24 h	5.90	5.97	0.047	NS
Temperature 45 min, °C	37.6	37.3	0.17	NS
Measurements at m. *Longissimus thoracis*				
Color				
L*	48.2	46.6	0.622	+
a*	1.04	1.05	0.176	NS
b*	5.33	2.27	0.277	**
C*	5.51	4.47	0.265	**
H*	78.4	66.7	5.532	NS
Water holding capacity, %				
Drip losses	0.83	0.89	0.088	NS
Thawing losses	7.36	6.90	0.449	NS
Cooking losses	20.05	19.30	0.697	NS
Total losses	28.9	27.0	1.091	NS
Shear force, kg	3.00	2.80	0.129	NS

[a] SE: standard error of the mean. [b] p: significance. NS: not significant ($p > 0.05$). +: $p < 0.10$. **: $p < 0.01$.

differences in some of these traits. In addition, a sensorial analysis would be interesting because possible differences in flavour might be found. However, the «sexual odour in females» is only a hypothesis and it has not been demonstrated.

Under our experimental conditions, it may be concluded that a low proportion of gilts were in oestrus when females were slaughtered at 130 kg BW, although the result might have been underestimated. The presence of oestrus in gilts at slaughter had scarce effect on carcass and meat characteristics. It did not affect the proportion of PSE/DFD meat but increased yellowness and intensity in meat colour. It also tended to reduce the proportion of suitable carcasses intended for PDO Teruel ham production because of a lack of backfat depth. However, new trials (with a higher proportion of replicates and also a sensorial analysis) would be needed before recommending the industry to avoid the slaughter of gilts in oestrus if a minimum covering fat is needed to improve the quality of the end product.

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